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Research Proposal

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Organization:	Department of Civil Engineering North Carolina State University

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Research Proposal: Multi-Year Travel Model Research
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EXECUTIVE SUMMARY

Our proposed project builds on the exciting new collaboration among the Triangle Regional Model Service Bureau, NC State University and UNC-CH, and upon on-going travel demand modeling research at the two Universities and ITRE. It addresses looming resource constraints within NCDOT as staff members in the Statewide Planning Branch meet transportation needs of all NC communities regardless of size. To simplify, streamline and standardize the travel demand modeling process we propose to develop guidelines for best practices for developing travel demand models and sub-models for trip generation, distribution, mode choice and assignment. In addition, we will develop recommendations for sources of relevant data, i.e., socioeconomic data, and we will undertake various kinds of validations of forecasts. These products and associated tools will help assure that NCDOT staff members efficiently use their time and resources to carry out their statewide transportation planning and modeling mission.

The study will last three fiscal years will have two phases of approximately 1.5 years each. In Phase I, instead of using the same expensive transportation, air quality and impact and analysis approach for all communities, we propose developing appropriately scaled approaches that reduce time and cost, yet provide adequate estimates of traffic volumes and impacts resulting from new transportation projects. For example, conventional NCDOT trend line traffic forecasts are adequate for isolated highway projects in very small communities and rural areas. In towns with populations between 1,000 and 5,000, traffic forecasts and manual allocation methods are appropriate. As the size of the study area grows, quick response software is valuable. Our research will determine what thresholds might be appropriate for quick-response methods. Such software often uses national averages for travel demand model parameters and significant data collection savings accrue. The research team will adjust national averages to North Carolina values as necessary based on analysis of North Carolina travel data. We will focus on the quick response methodology used in TransCAD, as NCDOT is already heavily invested in TransCAD. Phase II will deal with guidelines and tools for larger areas. As the study area becomes larger including one or more MPO's or RPO's with multiple modes, TransCAD software will be the recommended tool following current NCDOT practice. However, we anticipate that efficiencies are possible through standardized GDSK sub-models and GIS displays.

We propose a flexible multi-phase, multi-year research program that captures the expertise of NCDOT, the TRM Service Bureau, and the two Universities. Besides producing specific guidelines for using alternate travel demand model approaches depending on community size and/or needs, we will identify and develop sub-models and tools for carrying out travel demand model analysis. We will document our results appropriate for technology transfer and if necessary conduct one technology transfer seminar to introduce NCDOT to the results of the research. Since NCDOT personnel have indicated that they should lead actual training, we do not propose developing training courses and associated training materials in this project. Rather, such course development and delivery is more appropriate for a subsequent project in collaboration with NCDOT.

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RESEARCH PLAN

Introduction

Significant research on travel demand modeling is underway in the Statewide Planning Branch, NC State University and UNC-Chapel Hill. Engineers and planners in the Statewide Planning Branch prepare travel demand models for all NC communities, and staff in the Model Development Unit create improved tools and sub-models and present them in special courses. NC State recently completed three travel demand modeling projects and is currently working on two other projects, one of which is with UNC-CH (see attached reference list). The new Triangle Regional Model Service Bureau recently began development and maintenance of the TRM. In addition, the TRM Service Bureau serves as a focal point for student and faculty research on projects of mutual interest. Hence, our proposed project will be a collaboration among NCDOT, NC State, UNC-CH and the TRM Service Bureau. We expect this effort to be the first step toward a center of excellence in travel demand modeling practice and research for North Carolina and the Southeast.

This fortuitous collaboration of NCDOT, the Universities and the TRM Service Bureau will develop tools and techniques to help NCDOT meet the transportation planning needs of its customer cities, MPOs and RPOs. Furthermore, the collaboration will serve as a prototype partnership in transportation planning – the type of partnership toward which NCDOT is inexorably moving as state budgets shrink, state policies constrain hiring, and modelers become harder to hire. Indeed, the use of students at the two Universities during this and future projects with the TRM Service Bureau, as well as on-going graduate university classes, will help develop a new generation of modelers.

Fundamental to the success of this multi-year project will be a careful discussion of needs and expectations of NCDOT Statewide Planning personnel. Conversations with NCDOT have identified an explicit interest in using more simplified travel demand models than TransCAD if the planning area is sufficiently small. Phase I will focus on the smaller areas. We also know of new tools and sub-models under development by NCDOT staff to facilitate travel demand forecasting and the display and interpretation of results. Furthermore, as the TRM Service Bureau refines its needs and abilities with respect to this project, additional and continuing conversations will be necessary to define complementary efforts within this project. Based on NCDOT input, Phase II will focus on larger communities in North Carolina. Thus, while multi-year phasing, inter-institutional partnering, and general research topics will be discussed by our proposal, explicit tools will be defined during the initial stages of the project in collaboration with NCDOT and the TRM Service Bureau.

Subsequent paragraphs of this proposal will briefly discuss the research need, scope of work, anticipated research products, and how NCDOT will use the research products. The proposal will close with a budget estimate and citations of related research.

Research Needs

To address the transportation system needs of virtually all communities in North Carolina, NCDOT professionals develop analysis tools for forecasting future travel by automobile, truck and transit vehicles. NCDOT personnel also examine the contributions of pedestrians and bicycles to traffic and the direct effects of land use choices and patterns. While the fundamental NCDOT problem is one of estimating future traffic for land use and transportation options, NCDOT must also estimate impacts, costs and benefits of proposed transportation projects. Of particular concern are air quality impacts because of

health issues, federal mandates for clean air, and linkages to federal transportation funds. Other community impacts are also important, especially those related to the environment, economic development, and neighborhood access and identity.

NCDOT has the official responsibility to estimate personal travel, vehicular traffic, air quality, cost, environmental impacts and a variety of other related impacts for NC communities. In addition, NCDOT personnel work with communities to identify their needs in the evolving philosophy of context sensitive solutions (CSS). In CSS NCDOT listens carefully to community concerns, negotiates conflicting objectives among interest groups, and communicates transportation issues to the public by using a variety of graphics and tools related to this research. Throughout the analytical and outreach activities of the transportation planning process NCDOT professionals must integrate the results of the travel demand analysis with community specific features relating to neighborhoods, business areas, roadways, lakes and streams, recreational areas, schools and other features. They must also evaluate mitigation options and balance conflicting objectives of diverse interest groups.

To accomplish this varied and demanding mission Statewide Planning professionals have developed city and community transportation models, and they have begun to develop special sub-models (SWP Trip Generation and Synthetic External Trip Distribution) to simplify the modeling process for larger study areas. However, more needs to be done regarding sub-models for trip generation and for the remainder of the process including trip distribution, mode choice and network assignment. Air quality and benefit/cost analysis sub-models also require attention. Furthermore, alternative, simplified approaches need to be identified and verified for small to medium-sized communities consistent with their needs.

Besides developing sub-models for the modeling process, NCDOT has begun to develop specialized display tools for the results of the process so that community leaders can intuitively see and interpret tradeoffs between alternative transportation projects. These tools rely on the visualization capabilities of GIS methods that are usually customized for the particular study area. More can be done to develop standard GIS tools that can be applied to multiple study areas without customization. Furthermore, as simplified, even manual travel demand methods are developed for small study areas, appropriate GIS display and other tools will have to be developed to capture and communicate efficiently the results of the planning process for local citizens and officials to consider.

While the NCDOT Statewide Planning Branch has the ultimate responsibility to carry out the transportation planning process for communities, it relies on technical support (though not fundamental travel modeling) from other units in NCDOT, local agencies and consultants. The current heavy planning responsibilities and the expectation of increasing future responsibilities have forced NCDOT to consider other options to accomplish its mission. Indeed, NCDOT Statewide Planning has approached its own “cross roads” in transportation planning and modeling as “demands” for assistance exceed the resource and time “capacity” of its dedicated professionals. Its transportation planning options are becoming clear:

1. Continue to accomplish virtually all transportation models, impact assessments, and plan evaluations in-house with high level tools that require large investments of resources even for small communities,
2. Develop and use in-house a variety of appropriate sub-models and tools that fit the size and transportation needs of communities,
3. Sub-contract model development and plan evaluation for some communities to outside agencies and consultants, and/or
4. Develop partnerships to accomplish modeling research, appropriate sub-model and tool development, and plan evaluation.

These options are not mutually exclusive, and they can be simultaneously implemented. As discussed above NCDOT is currently following a combination of Options 1 and 2. Outreach to Triangle consultants

and subsequently to the TRM Service Bureau represents a first step toward Option 3. This proposal emphasizes the synergism that can result from Option 4 and the collaboration of NCDOT, the TRM Service Bureau and the Universities. Furthermore, Option 4 offers the future prospect of attracting graduate student interns and research assistants to build the professional capacity for modeling and planning that North Carolina needs.

Research Scope and Objectives

The proposed research project will build on previously successful project relationships between NCDOT, NC State University, and the University of North Carolina-Chapel Hill. It also depends on the anticipated expertise offered by the TRM Service Bureau. The proposed research will also build on the GIS, travel forecasting, and modeling expertise that the partners have demonstrated in a variety of NCDOT in-house and sponsored research projects as enumerated at the end of this proposal. The proposed research project may be considered a natural follow-on to the enumerated efforts. Yet, it will require the research partners to extend those projects to cover models, sub-models, tools, and guidelines for best practice for the spectrum of small to regional planning efforts.

The project goal is to improve the results of the planning process for all NC communities while making it a more efficient and less time consuming process, especially for NCDOT personnel. The project relies on U.S. census and North Carolina databases, proven sketch-planning methods, analytical methods tempered by expert judgment, and high-level transportation and GIS software that allow integration of multiple factors that affect community travel. This arsenal of tools will be appropriately applied to the variety of communities and their transportation needs in North Carolina. The project depends on the anticipated productive partnership of NCDOT, the Universities and the TRM Service Bureau.

The objectives of the proposed multi-year travel demand model research are:

- To improve, yet simplify, the transportation modeling process in North Carolina.
- To develop guidelines and tools for best modeling practices within North Carolina.
- To test the option of developing long term partnerships for research and transportation demand modeling using North Carolina expertise and data sets.

Literature Review

Throughout the proposal citations from the literature illustrate relevant work for this research. References 1-5 illustrate the inherent need for research to streamline the travel demand modeling process, especially for small study areas (Phase I). References 6-11 represent the more traditional, full-function travel demand modeling approach as currently practiced by NCDOT and other agencies (Phase II). References 12-15 discuss fundamental principles that must be adhered to in travel demand modeling. Special literature on small urban area needs and tools includes References 16-18.

Research Methodology and Tasks

The research methodology follows the well-known travel demand modeling approach: data collection, network development, trip generation, trip distribution, mode choice, trip assignment and impact analysis. We will apply this methodology with customized methods depending on the scope and size of the study area as we discussed previously (1, 8-10).

We will carry out the research methodology and objectives by a sequence of specific tasks that apply to simplified models as well as the more complicated models.

1. Organize the partnership for the TRM Service Bureau, the Universities and NCDOT.

2. Set expectations for the research and develop a flexible multi-year agenda.
3. Review the literature for best practices and select models and tools appropriate for North Carolina.
4. Procure needed software and organize a schedule to develop other methods and tools.
5. Define distinct categories for NC transportation study areas based on size primarily and other factors such as growth potential and types of transportation needs and/or required analysis.
6. Match travel forecasting approaches (manual, sketch planning, quick response, TransCAD) to the study area based on its size, its issues, and its transportation needs.
7. Determine available sources for model data including default national or state averages, and determine whether new surveys (of all types) are necessary.
8. Borrow or develop appropriate sub-models for trip generation, distribution, mode choice, traffic assignment, and external trip analysis.
9. Test the sub-models against newly collected data and available data sets such as those acquired by the Triangle Transit Authority (1995) and UNC-CH during the NCDOT trip generation study (2003).
10. Develop tools to enhance the graphic display of model results, transportation project evaluation and decision-making.
11. Demonstrate and verify the modeling approaches, sub-models, tools and guidelines with case studies previously accomplished by NCDOT.
12. Document the project and conduct a technology transfer with conference and journal presentations and publications.
13. Develop a one-day workshop (if needed) to present the findings of the research to NCDOT and "train the trainers".

Tasks 5 – 10 describe the research methodology that may be represented efficiently by a matrix as below. The purpose of the proposed research is to fill the matrix and identify best practices for modeling and planning in North Carolina. The research extends over multiple years because of the extent of the matrix. Using national average data and default methods for travel demand modeling, Reference 1 describes quick response methods for small towns and cities. It gives population thresholds for model applications in a manner similar to that illustrated by the matrix below. This research, however, will customize procedures for North Carolina and extend the concepts of Reference 1 to larger study areas.

Phase	**Population & Issues**	**Approach**	**Data**	**Net/ Zones**	**Trip Gen**	**Trip Dist**	**Mode Choice**	**Net Assig**	**Extrnl Trips**	**Tools**
I	< 5,000	Manual Trends & Forecasts	Default US, NC	Major Roads	US, NC Aves	Etc.	~	Etc.	Etc.	Etc.
I	5,000 – 10,000	Quick Response Software	US, NC Aves	Major Roads, Streets	NC, US Aves		GIS Tool			
I or II	10,000 – 50,000	TransCAD Quick Response	US, NC Aves	Major Roads, Streets	NC, US Aves		Off-Model Tools			
II	> 50,000	TransCAD	Local Data	Major Roads, Streets	Local Rates		Rate Adjs.			
II	Regional	TransCAD	Local Data	Major Roads, Streets	Local Rates		Mode Choice			

The matrix illustrates the research methodology – determine study area size, issues, needs or other characteristics to determine the approach; gather data; model the transportation network and analysis zones; conduct the travel demand modeling process (trip generation, trip distribution, mode choice and network assignment including external trips); and apply tools for impact assessment and decision-making.

Besides the size of the study area, the issues of concern to the community may determine the type of approach. While traditional highway needs may call for traditional approaches, contemporary issues related to economic growth, tourism, and small town revitalization may call for a mix of traditional and new tools and methods. Study area size, issues and needs will also affect the complexity of the choice of tools and models.

The five modeling approaches illustrated in the matrix are:
- Trend line traffic forecasts for small communities (References 2, 3, 9) with manual allocation models (References 1, 2, 16)
- Quick response manual or automated allocation models for small towns (References 8, 10, 12, 15, 16)
- Small urban sketch model implemented by the "quick response" TransCAD module or other quick response software (References 1, 2, 8, 16 17)
- City-wide travel demand models in TransCAD (References 8, 9, 10, 18)
- Regional models implemented by TransCAD (References 8, 9, 10, 15, 18).

The trend line forecast with manual traffic allocation is appropriate for very small urban areas or counties with little growth, no new highways, and available traffic data. The research can relatively quickly develop best practices for this row in the matrix. The travel allocation is appropriate for communities of up to 5,000 population with some anticipated growth and some needed highway facilities. Manual approaches may be simple spreadsheet sub-models or sub-models developed using GISDK scripting capabilities. Such manual models for population growth, trip generation, and internal and external trip distribution should prove helpful especially if they are coupled with "base map" GIS study area displays and aerial photography. The proven sub-models for the travel allocation approach are documented in NCHRP 365 and internal NCDOT tech memos. The GIS tools remain to be developed but can rely on standard GIS databases available from USDOT and NCDOT.

Approaches to small urban studies with populations between 5,000 and 50,000 may likely be implemented with quick response software. Hundreds of cities and agencies use QRS II and its associated Graphics Network Editor (GNE) software for integrated travel model analysis and presentation of results. QRS II and GNE are also compatible with a land use forecasting tool and with GIS data. The inexpensive software package can accept default national parameters, or it can use calibrated local parameters for its sub-models. Using similar default parameters the expensive TransCAD software implements a compatible quick response method. Indeed, the same example problems demonstrate QRS and TransCAD. However, NCDOT investment in TransCAD may argue for TransCAD as a seamless upgrade path for growing communities. Research products will likely include best practices for one or both of these packages, how and when to use simplified models with default national average data and parameters, and when to develop local community parameters for the models. Simplified display tools will also be developed, as needed. The development of approaches for small areas will constitute Phase I of our study.

Approaches to MPO and regional models will rely on TransCAD as they do currently. Products for best practices will focus on the application of this software, standard sub-models and display tools. To the extent possible, model structure might be shared and demand characteristics might be transferred between study areas to help achieve efficiencies at NCDOT and partner agencies. However, each MPO and region has their own distinct characteristics that may require customization. For example, depending on the needs of NCDOT in Phase II of our research, we can develop trip generation models that account for transportation and land use factors and apply them to the Triangle, Charlotte and other NC cities if appropriate. We can estimate trip generation models that break out trips into Home-Based Work, Non-Home-Based, and Home-Based Other trips, as usual. Data will come from the 1995 Triangle Transportation Survey (used for TRM calibration) as well as the Charlotte survey that we will combine with the Census Transportation Planning Package data. We will then develop specifications that will

include the traditional predictor variables for trip generation rates such as household size, number of vehicles in the household, household income level, type of home and also densities, mix of uses and design. This line of research inquiry can be particularly valuable in linking trip generation to land use by testing the effect of density and accessibility-related measures. Theory tells us that trip generation rates can vary with accessibility and density, and it is important to explore how elastic the travel-activity demand is with regard to changes in accessibility and development densities. Such developments will result in more accurate forecasts and stronger linkages with land use. Using other data sets such as those collected during the NCDOT trip generation study of tradition neighborhood developments, we intend to do similar development/calibration with trip distribution, mode choice and route assignment models and to transfer the results to other NC MPO and regional models.

ANTICIPATED RESULTS AND SIGNIFICANCE

During Phase I, an 18-month period, we propose that small communities be the focus and that the first two or three rows of the matrix be filled. Large communities and regional study areas will be the focus for Phase II and subsequent phases depending on the number of sub-models and tools developed and verified. This flexible approach to the research will allow the research team to define and work with precise needs of NCDOT and its customer communities. In addition, the flexible approach will permit the Universities to recruit outstanding students who can serve as research assistants and interns at the TRM Service Bureau.

More specifically the research products will include:

- Guidelines for appropriately matching travel demand modeling approaches to communities based on their size and needs.
- Guidelines for best practices during application of appropriate modeling approaches.
- Research, development and recommendations for performing sub-model analysis for those cells of the matrix.
- Case study demonstrations of the recommended approaches, sub-models and tools.

These products will allow NCDOT to match modeling and data collection methods to the scope and scale of each study area rather than using “full blown” 100% data collection and TransCAD modeling that are more appropriately used for large city and MPO studies. As a result, NCDOT will likely be able to more quickly produce transportation plans and updates at less expense.

Furthermore, this research project will provide an opportunity for valuable cross-institutional collaboration and for planning and engineering experts, interns and students from NC State, UNC-CH, the TRM Service Bureau, and NCDOT. The research represents a first collaborative step toward regional prominence in travel demand modeling.

RECOMMENDATIONS FOR IMPLEMENTATION AND TECHNOLOGY TRANSFER

NCDOT engineers have considerable experience in travel model development and traffic forecasting at the system level and project level. We anticipate that NCDOT can incorporate the new methods and tools into on-going NCDOT training programs for NCDOT staff, community planners and MPO staff. To facilitate the training we intend to write occasional “white papers” describing methods and tools as we develop them. Our interim report will document the research products for smaller communities, and the final report for the three-year research project will include step-by-step descriptions and examples of the methods and tools for large communities and regional study areas, as well as small communities. If necessary to wrap up the project, the Universities and the TRM Service Bureau will prepare and present a technical seminar on the research findings and forecasting methods. Other avenues for technology transfer

include conference and journal papers and distribution of the final report to state DOTs, consulting firms, and state and local agencies.

RESOURCES SUPPLIED BY NCDOT

The project team will maintain a close collaboration with NCDOT throughout the project. We anticipate that we will use and build on the tools, methods and databases that the Statewide Planning Branch and the Travel Model Development Unit have developed. Specific resources supplied by NCDOT will likely include: household surveys, travel models and databases for small, medium and large case studies. For example, the Charlotte survey may prove valuable. Additional surveys will likely be conducted by NCDOT in the normal course of their community and regional transportation planning and we request the opportunity to help structure the surveys to support this research, and we request the results of the surveys.

TIME REQUIREMENTS

Phase 1: 18 months; simplified approaches, sub-models and tools for small to medium-sized communities.
Phase 2: 18 months; full-scale approaches, sub-models and tools for larger communities and regional study areas.

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QUALIFICATIONS AND ACCOMPLISHMENTS OF RESEARCHERS

John R. Stone, PhD

Dr. John Stone is Associate Professor of Civil Engineering, North Carolina State University at Raleigh. He received Ph.D. in Civil Engineering, University of Virginia in 1981, an ME in Transportation Engineering, University of South Carolina in 1976 and an MS in Flight Mechanics, Princeton University in 1968. He has worked as instructor, USAF Training Command, 1968-1971; Project Engineer, Air Force Flight Dynamics Lab, Wright-Patterson AFB, OH, 1971-1975; Visiting Instructor, Air Force Institute of Technology, 1971; and Instructor, University of South Carolina, 1976-1977. His professional activities include American Society of Civil Engineers, Urban Transportation Division Executive Committee, Past Chair; Transportation & Development Institute, Planning and Development Council; Transportation Research Board; and Institute for Transportation Engineers, Traditional Neighborhoods & Traffic Engineering Committee 5P-8, Past Member. He has done extensive research on traditional neighborhood developments, multimodal transportation systems, transportation systems analysis, and modeling. Recently he has conducted research projects for NCDOT traffic forecasting at the project and systems levels. The American Society of Civil Engineers presented Dr. Stone with the 2003 Frank M. Masters Award "for demonstrated leadership in education and research related to public transportation, transportation safety and planning, and ASCE."

Asad J. Khattak, PhD

Dr. Asad J. Khattak is internationally recognized in transportation systems and planning. He is Associate Professor at the Department of City and Regional Planning, University of North Carolina at Chapel Hill where he also directs of the Carolina Transportation Program and teaches transportation planning and quantitative methods courses. He received his Masters and PhD degrees in Civil Engineering from Northwestern University in 1988 and 1991, respectively. He has worked at University of Oxford in England and Institute of Transportation Studies, University of California at Berkeley. He remains affiliated with University of California at Berkeley as a Visiting Scholar. Dr. Khattak has conducted and managed research (totaling more than two million dollars). He has authored forty-five scholarly journal articles and thirty research reports in transportation (for the federal DOT, Caltrans, and NC DOT). In his research, he has conducted 10 major surveys throughout the country to understand traveler behavior and has conducted extensive modeling of the data. He has explored issues related to working from home and how people change their trips in response to information. He has presented research at national and international conferences in France, Singapore and Canada. Dr. Khattak is the Editor-in-Chief for the *Intelligent Transportation Systems Journal*, Taylor and Francis Publishers. He is co-PI with Dr. Stone on the NCDOT project for estimating trip generation effects of traditional neighborhood developments.

Leta F. Huntsinger, PE, CPM

Ms Huntsinger brings extensive travel demand modeling experience to the research team. For three years she was Head of the NCDOT Model Research and Development Unit. The Unit was responsible for developing best practices and training for TransCAD for NCDOT and NC MPOs. Under her leadership her staff initiated many of the concepts that underlie this research, especially with regard to regional travel demand models. Recognizing her expertise in transportation systems modeling, Duke University hired Ms Huntsinger as Adjunct Professor of Civil and Environmental Engineering. Her responsibilities include teaching roadway design, traffic operations and transportation planning. Her broad experience covers nearly 20 years of progressive responsibility ranging from computer-based traffic studies for small communities to region-wide multimodal transportation models using TransCAD. The breadth of her experience and present position as Program Manager of the Triangle Regional Model Service Bureau make her uniquely qualified to work on this research. She holds memberships and leadership positions in

the North Carolina Section of the Institute for Transportation Engineers and the Transportation Research Board.

OTHER COMMITMENTS OF RESEARCHERS

J. R. Stone: NC Truck Traffic Forecasting, NCDOT, July 2003 - December 2004.
A. Khattak: Case-Based Reasoning, CalTrans, July 2002 - June 2004.
L. F. Huntsinger, Director of Triangle Regional Model Bureau.